5. The Scorpionidæ represent a form more ancient than the Araneidæ.

6. The Tetrapneumonous Araneidæ present more ancient forms than the Dipneumona.

7. The appendages of the Pycnogonidæ may be compared with those of the Arachnida, and the Pycnogonidæ resemble the Spiders in the structure of their generative and digestive organs.—*Annales des Sciences Naturelles, Zoologie*, sér. vi. tome xvii.

On the Physiology of a Green Planarian (Convoluta Schultzii). By M. A. Barthélémy.

Convoluta Schultzii is a singular animal, of a nature to excite the interest of those naturalists who pay attention to the function of chlorophyll. It is not one of those creatures of doubtful position and, so to speak, intermediate between the two kingdoms, but a comparatively high organism, in which the association with chlorophyll elements has produced interesting physiological peculiarities. By the extreme kindness of M. Lacaze-Duthiers I have been enabled to study this interesting creature, which lives and develops in abundance at Roscoff. Its anatomy, and especially its embryogeny, must be the subject of a special investigation ; I shall content myself in this note with speaking of its physiology.

I shall only state that this *Convoluta* presents a ciliated cuticle, a muscular layer giving origin to longitudinal bands, and a central parenchyma replacing the digestive tube. There is neither mouth nor œsophagus, and still less an anus. This construction resembles that of the Infusoria, especially of *Opalina*.

As regards the chlorophyll element, it is represented by cells with greenish-yellow contents, and presenting a nucleus which is brought into view by attacking the chlorophyll with ether and then treating with potash. These elements are free upon the surface of the central parenchyma, and when the latter escapes, in consequence of an accidental rupture, it is not uncommon to see one of these cells also escape surrounded by protoplasm. It seemed to me that these chlorophyll-cells multiplied by division of the nucleus.

I must not forget to mention the existence (which, however, is not constant) of fusiform bacilli inserted into the cuticle by a sort of nail-head, and often collected, to the number of four, at the posterior part of the animal; and, lastly, of bundles of very fine, granular, parasitic Nematodes, much attenuated at the extremity, which live and move for some time when detached from the animal; but I do not know whether it is to these that we must refer the nematocysts with protractile filaments that Gräff has described in *Stenostomum Sieboldii*.

When held between the fingers, the animal diffuses a phosphorous

odour, which reminded me of that of the *Suberites* upon the beach at Banyuls.

To sum up, the *Convoluta*, by the absence of the digestive tube, the œsophagus, and even the mouth, by the activity of its ciliary movements, and by the layer of chlorophyll-cells, has the appearance of a physiological association, a symbiosis between a unicellular alga and an acœlate worm.

Thanks to the presence of the chlorophyllian element, the animal can live in a medium deprived of air, in stagnant pools where life would be impossible, while, by its vibratile movements, it constantly furnishes the plant with the current of carbonic acid necessary for its nutrition, and of which, in its turn, it utilizes the oxygen originating from the chlorophyllian function.

The physiology of *Convoluta* is necessarily reduced to endosmotic exchanges, through the external cuticular layer, of liquid nutritive substances and gaseous solutions.

The act of respiration has been the subject of a full investigation made with much care by Mr. Patrick Geddes *. However, being governed by ideas which are still current in vegetable physiology, he has sought to collect and analyze the gases which *seemed* to him to be evolved from these little organisms under the action of the sun; and, further, his researches were made upon a quantity of animals so considerable (a surface of one third of a square metre covered with Planarians) that it is impossible to draw deductions from them as to the individual life of each.

The first fact that strikes the observer after placing a certain number of the *Convoluta* in a series of flasks is the tendency that they have to move towards that part of the room, or rather of the flask, which is most strongly illuminated. It is an *organic photometer* of extreme sensibility.

These worms are destitute of visual organs, even rudimentary; but if it is true that vision in the higher animals is only the result of chemical action, a decomposition of the retinic purple, we may assume that the action of the chlorophyll upon carbonic acid produces a sort of visual sensation in the animal. It is to be remarked that the ascent of the Planarian takes place slowly, and, so to speak, unconsciously, under the influence of movements of the vibratile cilia more energetic in the direction of the light. On arriving at the surface of the water our worms attach themselves by their posterior part; but at the least agitation of the water or the vessel they detach themselves and fall to the bottom with very precipitate movements.

As regards the emission of gases and the deductions that can be drawn from them to furnish evidence, or the measure, of the respiratory act, I can assert that it does not exist. We have only to avail

* Arch. Zool. Exp. tom. viii. 1879–80.

ourselves of the action of light just indicated, to attract to the most illuminated and *most elevated* point in the vessel all the Planarians, when we can convince ourselves that the fine bubbles of gas of which Mr. Geddes speaks start from the particles of sand or the organic fragments of the lower part of the vessel. On examining with the lens the green mass formed by the *Convolutæ* we cannot detect any gas-bubbles. Could it be otherwise with the continual movement of the vibratile cilia, which is opposed to the *formation* of the bubbles? and in the absence of any internal cavity in which the gases could accumulate or circulate?

The giving off of oxygen in the gaseous state would presuppose a respiratory activity out of proportion to the small quantity of chlorophyll presented by our Planarians, even when collected into a great mass.

The bubbles obtained by Mr. Geddes presented from 43 to 52 per cent. of oxygen, the rest being nitrogen. It seems to me that this residue of nitrogen must not be neglected, and that it would be necessary to assume that besides the 40 per cent. of oxygen, our worm excretes 60 per cent. of nitrogen of unexplained origin. It must further be remarked that the analysis of the gases dissolved in sea-water presents great difficulties and has not yet been made in a satisfactory manner*.

In reality, no completely aquatic plant or animal evolves gases under normal and regular conditions, and the *Convoluta* forms no exception to this law.

In an excess of carbonic acid aquatic plants do not set free oxygen except when they possess air-ducts and the leaves are detached from the stalk, or when they have retained a layer of air at the surface. In presence of an abnormal quantity of carbonic acid, the *Convolutæ* produce very small granules of amylaceous matter which are deposited in the mesoderm. If the excess of carbonic acid be too great the animals are destroyed; then the association is broken up and the unicellular alga undergoes a new evolution, the course of which has still to be traced.

Thus the respiratory act in *Convoluta Schultzii* consists in the absorption through the cuticle of carbonic acid in solution, which the chlorophyll decomposes with production of oxygen. The latter is utilized by the animal in whole or in part, so that if oxygen is exhaled it can be only in very small quantity and not in the gaseous state under normal conditions. This respiration presents a striking analogy with that of submerged aquatic plants, such as we must now-a-days conceive it to be.—*Comptes Rendus*, July 28, 1884, p. 197.

* See 'Revue Scientifique,' June 21, 1884, and later.